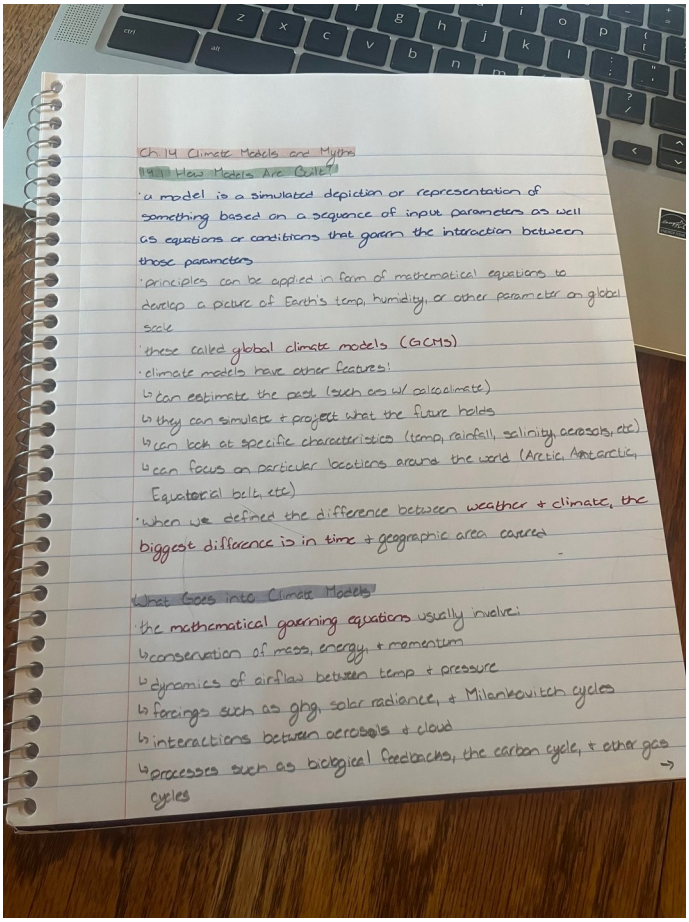


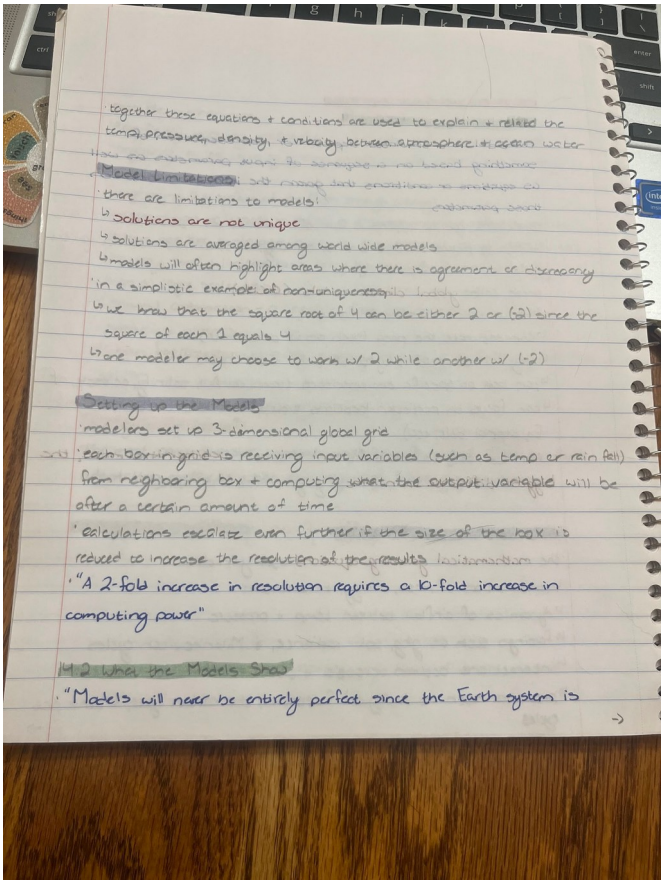
Ch 14 Climate Models are Myths

14.1 How Models Are Built

- a model is a simulated depiction or representation of something based on a sequence of input parameters as well as equations or conditions that govern the interaction between those parameters
- principles can be applied in form of mathematical equations to develop a picture of Earth's temp, humidity, or other parameter on global scale
- these called global climate models (GCMs)
- climate models have other features:
  - ↳ can estimate the past (such as w/ paleoclimate)
  - ↳ they can simulate & project what the future holds
  - ↳ can look at specific characteristics (temp, rainfall, salinity, aerosols, etc)
  - ↳ can focus on particular locations around the world (Arctic, Antarctic, Equatorial belt, etc)
- when we defined the difference between weather & climate, the biggest difference is in time & geographic area covered

What Goes into Climate Models

- the mathematical governing equations usually involve:
  - ↳ conservation of mass, energy, & momentum
  - ↳ dynamics of airflow between temp & pressure
  - ↳ forcings such as ghg, solar radiance, & Milankovitch cycles
  - ↳ interactions between aerosols & cloud
  - ↳ processes such as biological feedbacks, the carbon cycle, & other gas cycles →



together these equations + conditions are used to explain + relate the temp, pressure, density, + vapor between atmosphere + ocean water

- Model Limitations:
  - there are limitations to models!
    - ↳ solutions are not unique
    - ↳ solutions are averaged among world wide models
    - ↳ models will often highlight areas where there is agreement or discrepancy
  - in a simplistic example of non-uniqueness
    - ↳ we know that the square root of 4 can be either 2 or (-2) since the square of each 2 equals 4
    - ↳ one modeler may choose to work w/ 2 while another w/ (-2)

Setting up the Models

- modelers set up 3-dimensional global grid
- each box in grid is receiving input variables (such as temp or rain fall) from neighboring box + computing what the output variable will be after a certain amount of time
- calculations escalate even further if the size of the box is reduced to increase the resolution of the results (miniaturization)
- "A 2-fold increase in resolution requires a 10-fold increase in computing power"

M.2 What the Models Show

- "Models will never be entirely perfect since the Earth system is

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"inherently chaotic & behaves in a nonlinear fashion"

- most models aim to show the characteristics of the atmosphere & ocean that are measurable & have some kind of impact on our environment
  - ↳ temp or changes in temp from 1 year to next
  - ↳ sea level or the rate of sea-level rise
  - ↳ ice melt or rate of ice loss
  - ↳ pH or variability in pH over time
  - ↳ rainfall or changes in rainfall over time

RCPs (Representative Concentration Pathways)

- reports that appear in climate publications often refer to RCPs (Representative Concentration Pathways).
- future trajectories put together by 4 major modeling teams of the ghg concentrations or forcings that models use to determine scenarios of future climate
- ex of pathways:
  - ↳ **RCP8.5**: in this scenario, a model is calculated that assumes high ghg emissions w/o any change in climate policies. As expected, w/ the burning of fossil fuels at current rates of increase we would expect much higher temps by 2100
  - ↳ **RCP2.8**: in this scenario CO_2 increase to a certain point & then declines. This might be the expected case if it took a while for climate policies to take as the world converts to cleaner energy sources
- there are 2 other RCPs: RCP4.5 & RCP6.0

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- RCPs are increasingly adopting Shared Socioeconomic Pathways (SSPs) that reflect climate policy directions

Where the Models Disagree

- climate models are continuously being modified & improved as more data is collected
  - ↳ why are they different?
  - ↳ are they really that different from each other?
- recent work has looked at model genealogy to see how they have evolved

1. Same Code but Different Inputs. Some models might use the same (or similar) code but run w/ different input parameters to see how the model treats the data. When the same code is run, particularly when different organizations use it, then it means that there is general agreement among scientists as to the governing physics involved in a specific process. In this case, 1 group running the codes expects CO_2 to drop while another group might expect methane to go up faster
2. Different Code w/ Same Inputs. in this case, different streams usually refer to how portions of the code might interact w/ other pieces of code. Scientists will often set up reference inputs that remain the same for all the runs. In this way, they can see how their model changes when they change subsets of their code. This helps them to understand how different systems affect 1 another. Ex: melting ice will affect how much fresh H_2O goes into the ocean in the Arctic which in turn affects the salinity & plankton blooms. (I might've considered the plankton blooms in a downstream process

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while another run doesn't consider the biological processes.)

CLOUDS

- clouds:
  - ↳ can both reflect & absorb heat
  - ↳ throw heat into space or have it radiate back to earth
  - ↳ thick low lying clouds behave differently from high thin clouds

Where the Models Agree

- "while there are certainly differences between the climate models around the world, they all point to a warmer future, rising seas, & enhanced hydrologic cycle."
- "the greatest similarities between models often have the following factors in common:
  - ↳ they are often generated at the same institution
  - ↳ they are using the same code but may use different variables (e.g. satellite vs. ground measures).

Are the Models Reliable?

- reliability of models is generally tested through hindcasting
- observations help to:
  - ↳ reinforce model performance for current conditions
  - ↳ provide input back into the models for future projections
- forecasts deal w/ probabilities of occurrence, in contrast to predictions that provide a very accurate & precise statement of what will happen at a particular →

place + point in time

14.3 Myths and Data Misrepresentation

"there are 3 kinds of lies: lies, damned lies, + statistics." - Mark Twain

the limitations or variability among models can turn into misinformation + myths, as it so often does in the news + on social media

once in a while misinterpretation can occur w/ your research, due to:

↳ Small sample size: the sample doesn't represent the population of data

↳ Flawed correlation: studies can be manipulated (w/ enough data) to prove a ~~[illegible]~~ correlation that doesn't exist or ~~[illegible]~~ commonly, that's linked ~~[illegible]~~ significant enough to be valid ~~[illegible]~~

↳ Bias: personal bias can affect the outcome of their studies w/ flawed conclusions. May happen by omitting data to make correlations appear more significant. The fit is what you already think or what you hope the results be

↳ Misleading data visualization through graphical manipulation: this is when an author distorts or misuses the visualization tools to create false conclusions using correct data. These are by far the most insidious tricks used by subjective news outlets, bloggers, + various, unscrupulous websites. Once exposed to these tactics they become easy to spot

applying the scientific method is so important in science

Changing Scales

Truncated Graphs

Broken Axis

3D Pie Charts

Raw versus Cumulative Data

- raw data just what it sounds like, resulting in a bar chart or histogram, & clearly shows whether some variable is increasing or decreasing.
- cumulative plot is the sum of the previous values

New Ways to Deliver Complex Information

- Animation (Active Engagment)
- some new visualization displays invite the viewer to engage w/ the graphs & plots
  - ↳ series of graphs
  - ↳ regional or map data

Ch. 15 What Can YOU Do?

15.1 Innovations and Entrepreneurs

Sustainability

- Sustainability is the ability to meet the needs of present w/o compromising the ability of future generations to meet their own needs
- if we gamble on using nonrenewable resources w/o a smooth transition into renewable, then we risk the ability for future generations to develop renewables when the nonrenewables run out

Biodiversity Boost with the Half-Earth Project

- initiative proposes to set aside ½ of all oceans + land for conservation, free from development

Addressing Food Security

- main factors affecting food availability include:
  - ↳ changes in climate, urbanization, land availability, + access to freshwater
- in order to meet our future food needs, reducing food waste is an important part of our solution since we waste around 30% of all the food that is produced. Paul Hawken
- new farming techniques to help change:
  - ↳ Drone + satellite assisted farming: drone + satellite videography can quickly highlight the health of plants so that farmers can quickly target areas that require more attention. Plus, some of the larger drones are able to supply nutrients to specific areas in the field saving farmers time + money. Another new + exciting development is in the delivery of pollen that helps augment production when bees are in short supply. All of these applications focus on efficiency for the farmer

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- ↳ Indoor farming: large warehouses provide a controlled environment where crops can be grown on stacked pallets or even vertically. Sensors & instruments can continuously measure the health of plants & provide moisture & nutrients as needed. In these controlled environments it is possible to grow organically w/o the use of pesticides
- ↳ Genetically Modified Plants: plants that can withstand changes in our climate (heat, drought, & the associated pests) will undoubtly be at an advantage over existing crops. New research is exploring new strains of crops to deal w/ these changes. Crossbreeding & genetics are tools that have been around for a long time & will be exploited further
  - one of the more remarkable individuals who is sometimes credited w/ averting the starvation of 1 bil people by doubling crops yields in several countries is Norman Borlaug
- ↳ Cover crops to fight climate change: these agriculture products might not be consumed but by planting other species between rows of crops you minimize run-off & boost carbon sequestration from the atmosphere. Plus, filling in soil w/ additional plants enables the soil to retain more moisture

- Soil carbon sequestration has the potential to offset fossil fuel carbon emissions by up to 15%

Energy from Ocean Seaweed

- a new resource being considered for energy is seaweed

Mushrooms that Feed on Waste

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- one interesting natural remedy that is a master of feeding on waste is the mushroom
- Paul Stamets proposed using mushrooms to help clean up waste sites
- using mushrooms is a form of phytoremediation, where plants sequester or breakdown contaminants in the environment.
  - ↳ mushrooms used called mycoremediation
- some potential mushrooms:
  - ↳ oyster mushrooms: could clean up oil spills all over the planet
  - ↳ agaricon mushroom: could provide a defense against weaponized smallpox
  - ↳ mycena alcalina (a tiny grey mushroom): releases chlorine gas that suggests it can break down toxic chlorine-based polychlorinated biphenyls or PCBs
- New research is looking at how mushrooms can even deal w/ nuclear waste through bioaccumulation

15.2 What You Can Do

- people can play their part in minimizing their impact on the future climate by:
  - ↳ voting & supporting candidates that promote climate-friendly policies
  - ↳ recycling everything as much as possible
  - ↳ volunteering for environmental or conservation organizations
  - ↳ educate a girl - the act of support education for women, particularly in developing countries, is well known to help families make smarter choices in managing their lives
  - ↳ eat food for the season by minimizing the transportation costs of having all foods available year-round

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↳ transportation - use public transportation, bicycle, or walk whenever possible + transition to electric

↳ develop coastal managed retreat plans - if you live on coast, know when + how to retreat from rising seas.

↳ be conscious of the impact of every action you take

· We only have 1 planet to share. Let's make it last

What is a Climate Model?

- climate model is like a virtual Earth designed to mimic earth
- computerized representations of components that represent atmosphere, ocean, ice, etc
- Parameterizations
  - ↳ important uncertainty
- attribution - determine likely causes of observed climate change
  1. scientists 1st use climate models to estimate how outside influence should have caused the climate to change
  2. then use statistical tools to look for expected patterns of change in climate observations gathered over the past 50-100 years or longer
- ghg, aerosols, volcanic activity

Survivable IPCC projections based on science fiction

- RCP 2.6 & RCP 4.5
- RCP 8.5 - current path and unsurvivable
  - will lose trees & ice
- carbon dioxide removal

IPCC Projection of Temperature and Precipitation in the 21st Century

- largest temp increase in N Hemisphere
  - ↳ North America anywhere w/ snow
- losing snow/ice = change in albedo (less)
- precipitation changes everywhere